Journal Name

ARTICLE

Extraction of Nb(V) by quaternary ammonium-based solvents: toward organic hexaniobate systems

Received 00th January 20xx,
Accepted 00th January 20xx

DOI: 10.1039/x0xx00000x

www.rsc.org/

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SUPPORTING INFORMATION

Table S 1 : Extraction yield of Nb for various quaternary ammonium salts. Initial aqueous phase: 3.4 mM $Na_7HNb_6O_{19}{\cdot}15H_2O$, pH = 12 (NaOH 10 mM). Initial organic phase: 44.7 mM of quaternary ammonium diluted in Elixore 205 + 1% (v/v) isotridecanol. Extraction: 1 contact, V_{org}/V_{aq} = 1, t = 30 min, T = 25 °C.

Quaternary ammonium salt	Nb Extraction yield
Aliquat® 336[a]	≥ 99.9 %
Methyltrioctylammonium chloride[a]	≥ 99.9 %
Methyltrioctylammonium bromide[a]	94.0 %
Sulfated Aliquat® 336[b]	≥ 99.9 %
Carbonated Aliquat® 336[c]	≥ 99.9 %
Hydroxide of Aliquat® 336[d]	≥ 99.9 %

a: commercial compound. b: obtained by pre-contacting the solvent with 1 M H_2SO_4 for 30 min (V_{org}/V_{aq} = 1/3). c: obtained by pre-contacting the solvent with 1 M Na_2CO_3 for 30 min (V_{org}/V_{aq} = 1/3). d: obtained by pre-contacting the solvent with 1 M NaOH for 30 min (V_{org}/V_{aq} = 1/3).

Table S2. Influence on the nature if the alkali cation on the extraction yield of hexaniobates. Initial aqueous phase: 0.18 mM $Na_7HNb_6O_{19}{\cdot}15H_2O$ + 50 mM ACl and 10 mM AOH (A = Li, Na or K). Initial organic phase: 9.0 mM of Aliquat® 336 diluted in Elixore 205 + 1% (v/v) isotridecanol. Extraction: 1 contact, V_{org}/V_{aq} = 2, t = 15 min, T = 25 °C.

Alkali system	Nb Extraction yield
LiCl/LiOH	94.4 %
NaCl/NaOH	90.7 %
KCl/KOH	89.5 %

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Electronic Supplementary Information (ESI) available: [details of any supplementary information available should be included here]. See DOI: 10.1039/x0xx00000x

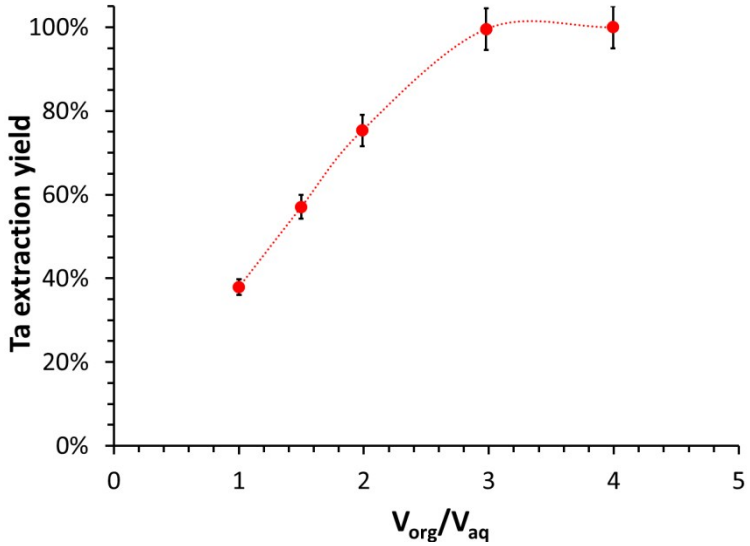

Figure S1. Extraction yields measured for Ta as a function of the volume phase ratio. Organic phase: 8.84 mM Aliquat® 336 diluted in Elixore 205 + 1% (v/v) isotridecanol. Initial aqueous phase: 3 mM $Na_8Ta_6O_{19}{\cdot}24.5H_2O$. Background electrolyte: 10 mM NaOH. Extraction: 1 contact, t = 30 min, T = 25 °C, pH_{eq} = 11.9 ± 0.1. Error bars: ± 5%.

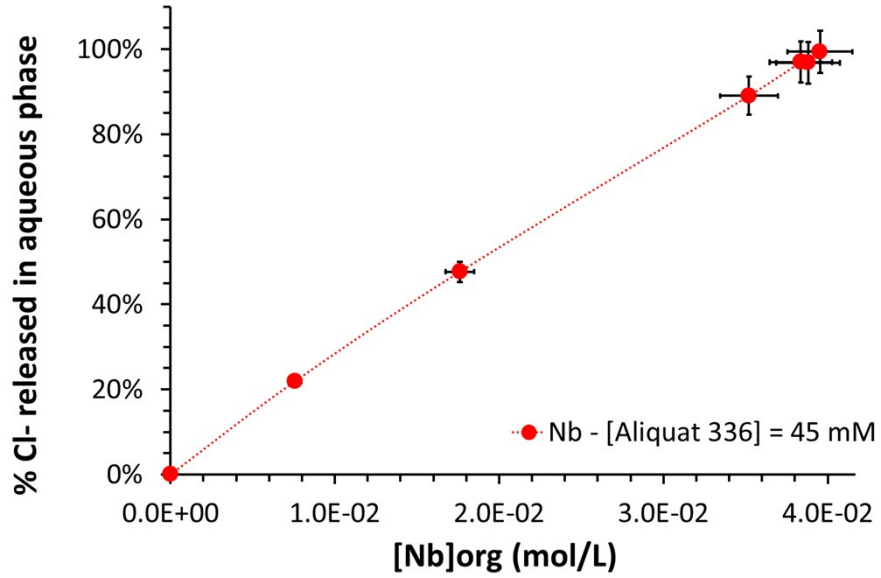

Figure S2. Percentage of chloride ions released by Aliquat® 336 (quaternary ammonium chloride) during the extraction of hexaniobate ions. Initial organic phase: 44.7 mM Aliquat® 336 diluted in Elixore 205 + 1% (v/v) isotridecanol. Initial aqueous phase: $Na_7HNb_6O_{19}{\cdot}15H_2O$ dissolved in 10 mM NaOH 10 mM (pH_{eq} = 11.9 ±0.1). The volume phase ratio ($V_{organic}/V_{aqueous}$) was varied from 0.25 to 2.7. Extraction: 1 contact, t = 30 min. Error bars: ± 5%. T = 25 °C.

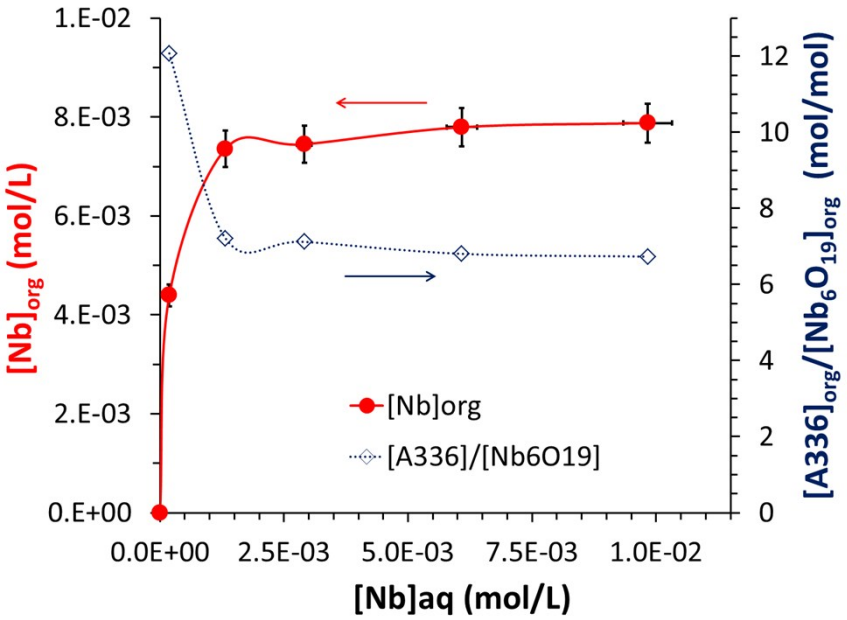

Figure S3. Extraction isotherme for $Na_7HNb_6O_{19}{\cdot}15H_2O$. Red curve, left axis: Concentration of Nb in the organic phase as a function of the concentration of Nb in the aqueous phase. Blue-dotted curve, right axis: corresponding ratio extractant/hexaniobate in the organic phase. Initial organic phase: 8.84 mM Aliquat® 336 diluted in Elixore 205 + 1% (v/v) isotridecanol. Initial aqueous phase: 3 mM $Na_7HNb_6O_{19}{\cdot}15H_2O$ dissolved in 10 mM NaOH 10 mM (pH_{eq} = 11.9 ±0.1). Different volume phase ratios were used ($V_{organic}/V_{aqueous}$ = 0.75 to 4.0) in order to obtain various concentrations of Nb in the organic phase until the solvent was saturated in hexaniobates. Extraction: 1 contact, t = 30 min. Error bars: ± 5%. T = 25 °C.